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# Atomic Resolution Observations of Heavy Atom Adsorbates on Low Atomic Number Substrates

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# Abstract: Atomic resolution observations of heavy-atom adsorbates on low-atomic-number substrates\*

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The feasibility of utilizing a high-resolution scanning transmission electron microscope (STEM)<sup>1</sup> to study the adsorption and diffusion of heavy atoms on low atomic number substrates is being investigated. It is shown that the study of surface phenomena on an atomic scale may be possible with the STEM.<sup>2</sup> The technique should be complementary to existing methods of studying surfaces at atomic resolution since the STEM is capable of observing substrate-adsorbate systems not easily accessible by other methods.

Two types of measurements which can be performed with existing instrumentation have been demonstrated. They are (1) the measurement of the spacing distribution of adatoms deposited onto substrates, and (2) the measurement of the diffusion of individual adatoms on substrates. Initially, our attention has been concentrated on thin evaporated carbon film substrates and solvent evaporated heavy atom-containing molecules as adsorbates, because of the ease of preparation of such samples. However, one should be able to extend the method to any substrate that can be made of small enough mass thickness and any adsorbate that can be visualized.<sup>3</sup>

We have (1) found that uranium and silver atoms deposited at low concentrations (from  $7 \times 10^{-4}$  atoms/ $\text{\AA}^2$  to  $5 \times 10^{-3}$  atoms/ $\text{\AA}^2$ ) exhibit preferential spacings with respect to one another (the pair-spacing distribution is peaked), and (2)

measured the thermal hopping of uranium and silver atoms on carbon substrates (deposited from dilute solutions of  $\text{UO}_2\text{Cl}_2$  and  $\text{AgCN}$ , respectively) at room temperature. For the uranium atom samples, we have observed a tendency for atom pairs to move together as a unit. In addition, we have shown that the effects of electron beam induced motion for the samples observed are (within our experimental error) negligible.

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<sup>2</sup>M. Isaacson and N. W. Parker, in *IITRI/SEM/76 Vol. I*, edited by O. Johari (IITRI, Chicago, 1976), p. 345.

<sup>3</sup>A. V. Crewe, J. Langmore, and M. Isaacson, in *Physical Aspects of Electron Microscopy and Microbeam Analysis*, edited by B. Siegel and D. Beaman (Wiley, New York, 1975), p. 47.